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[54] **SHUT-IN SPRAY GUN FOR HIGH PRESSURE WATER BLAST CLEANING**

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[51] **Int. Cl.**[6] **F16K 39/02**; B05B 1/30

[52] **U.S. Cl.** **137/454.6**; 251/282; 251/295; 239/526; 239/586

[58] **Field of Search** 137/454.6; 251/282, 251/295; 239/526, 583, 586

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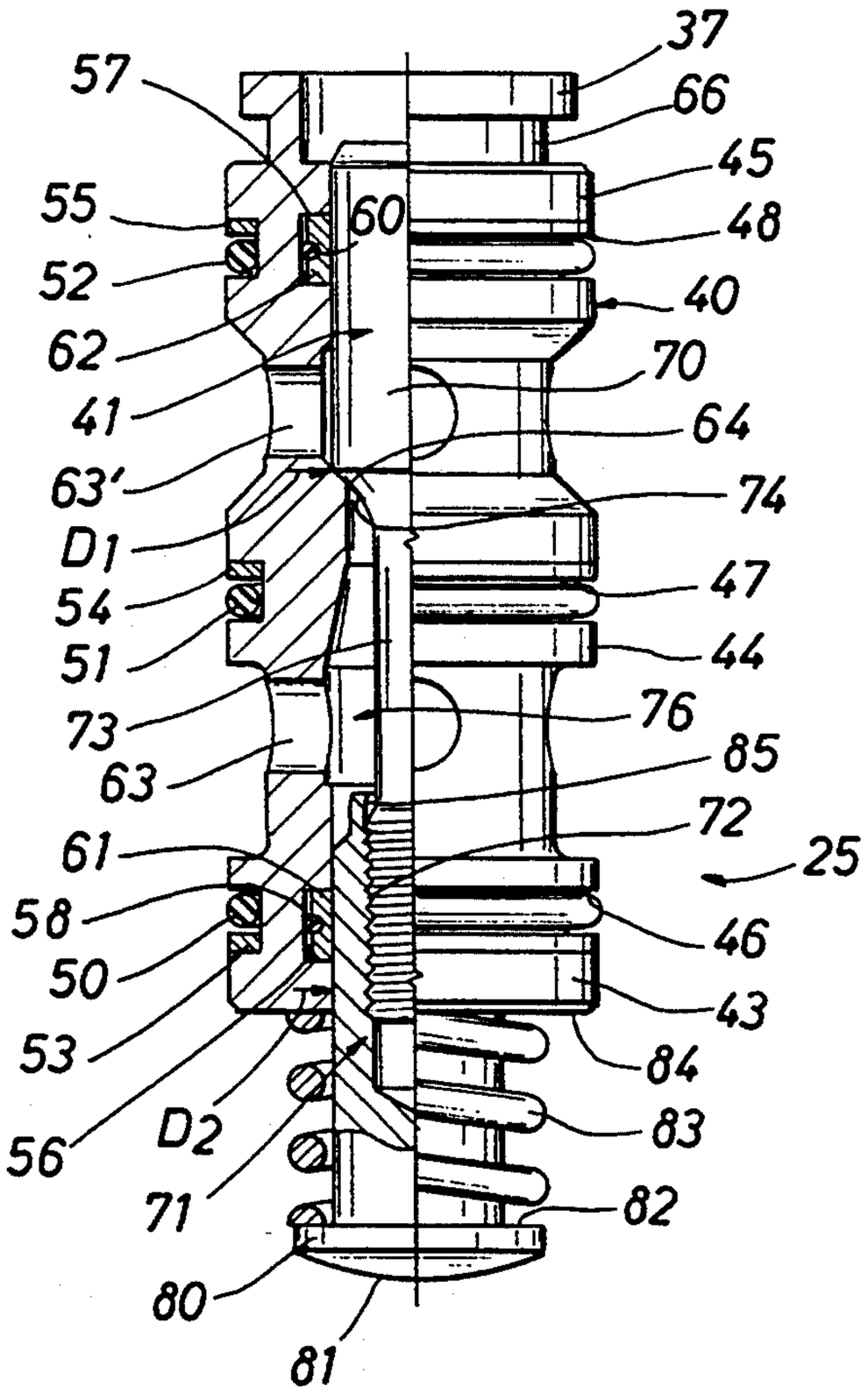
[57] **ABSTRACT**

In accordance with an illustrative embodiment of a high pressure water blast gun as disclosed herein, such gun includes a valve body having inlet and outlet ports and an internal chamber, and a removable valve cartridge in the chamber which includes a guide tube and a valve closure element slidably arranged in the tube. The closure element includes a leading end portion having a peripheral edge that engages an inclined seat surface in the guide tube with line contact on a first diameter, and a trailing end portion which is sealed against the guide tube on a second diameter which is greater than the first diameter to provide a hydraulic bias force that tends to close the valve against the seat. Both hand and foot operated embodiments are disclosed.

19 Claims, 2 Drawing Sheets



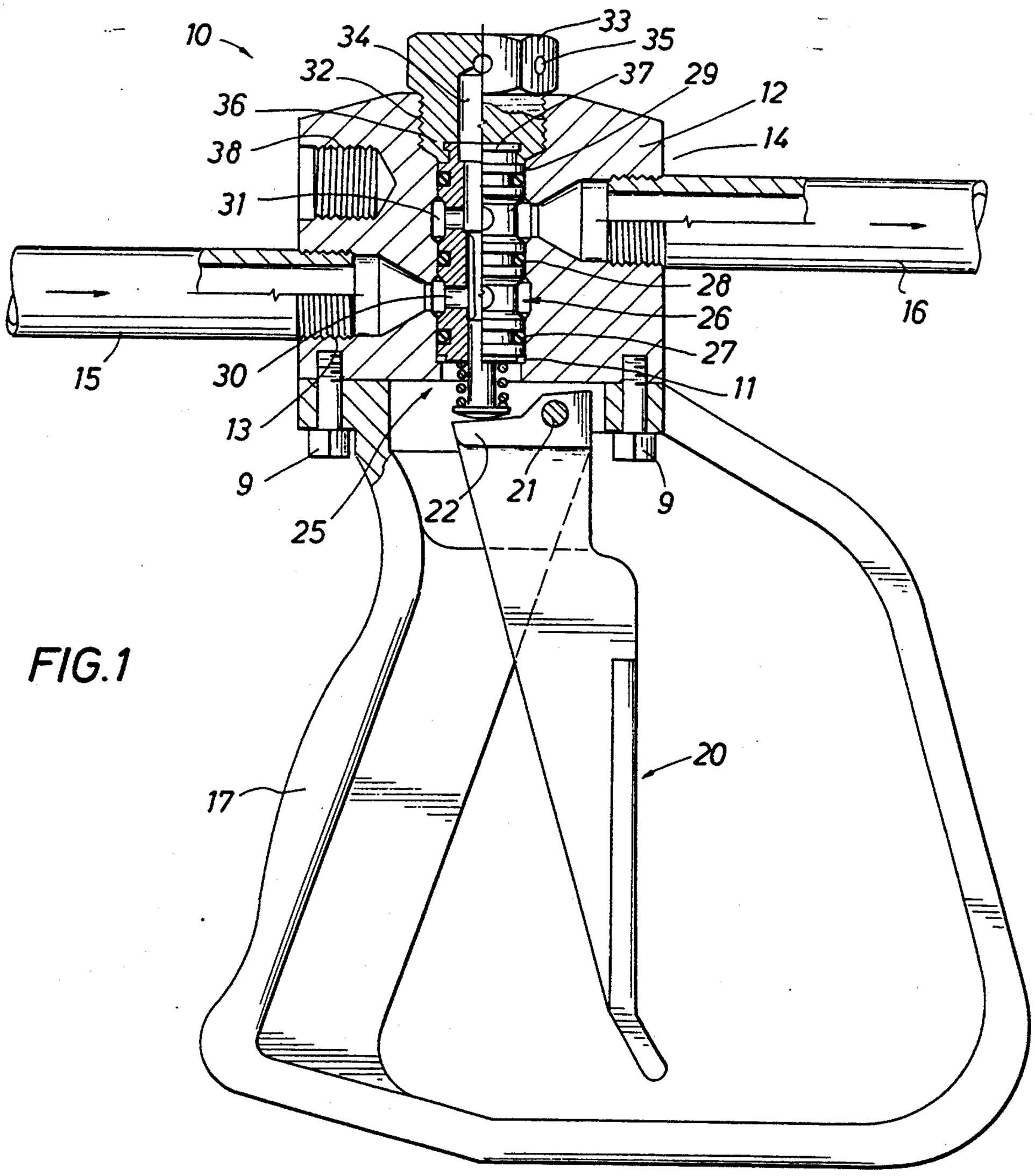

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FIG.1

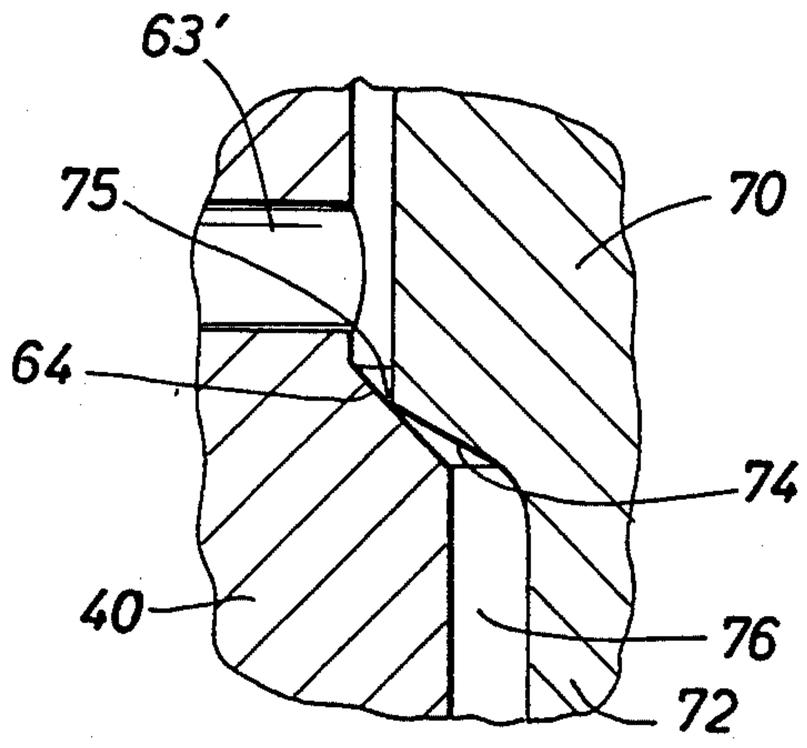
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FIG. 3

FIG. 2

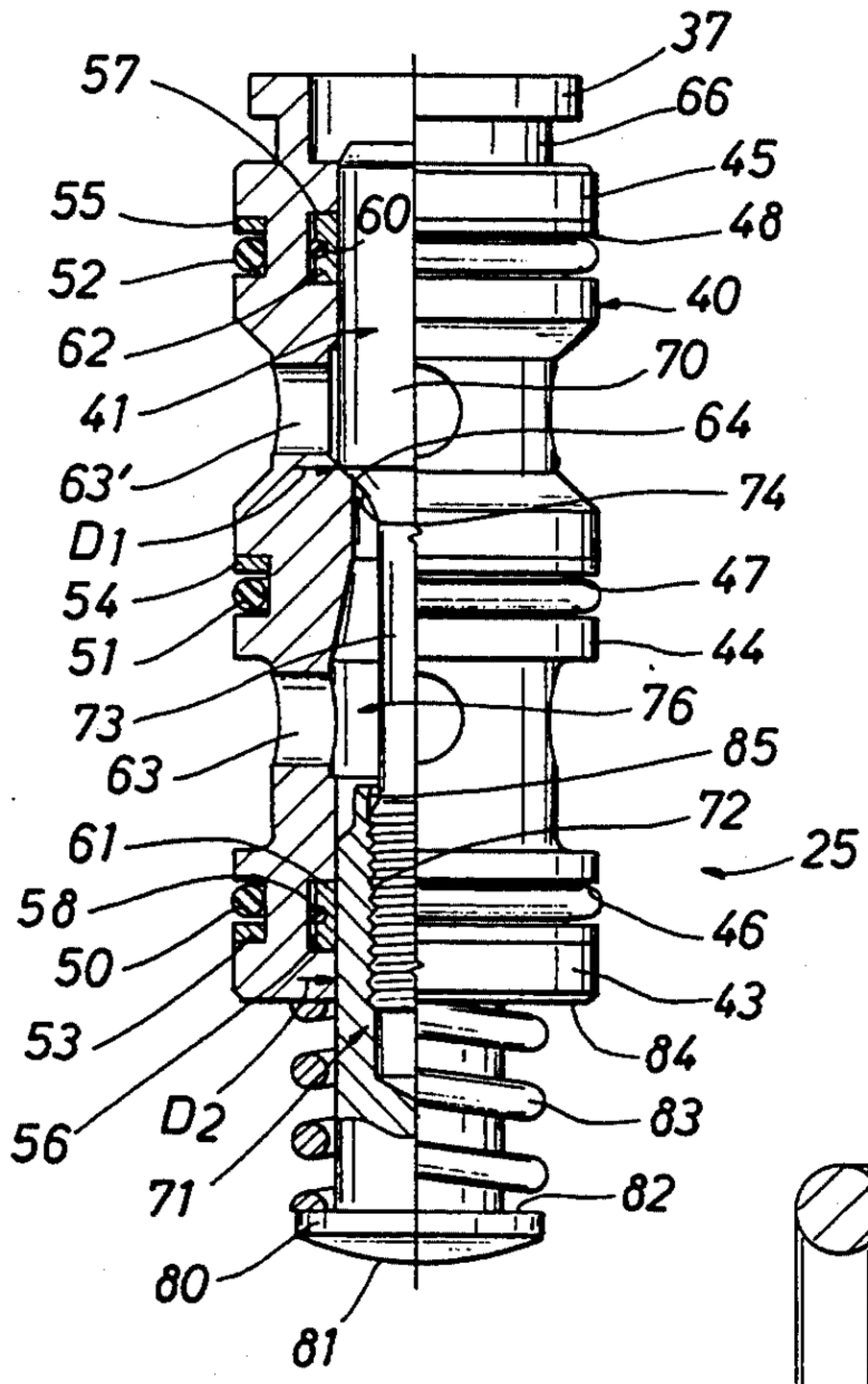
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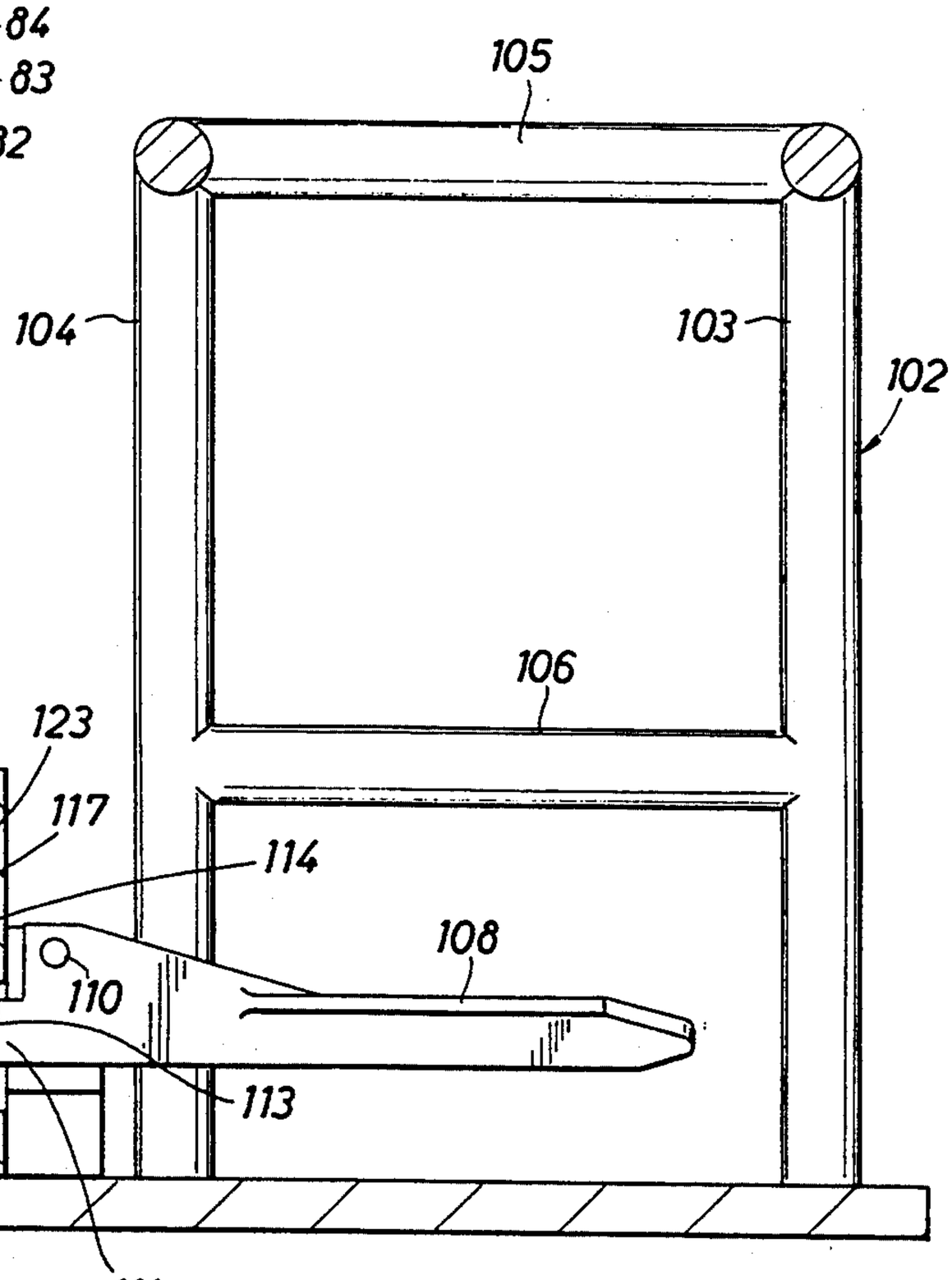
FIG. 4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SHUT-IN SPRAY GUN FOR HIGH PRESSURE WATER BLAST CLEANING

FIELD OF THE INVENTION

This invention relates generally to a spray gun and valve system for directing a high pressure blast of a fluid such as water against various surfaces such as concrete, metal, and the inside of tubes and vessels in order to clean coatings, deposits, seals and other unwanted deposits therefrom. In particular the present invention relates to a gun assembly of this type which has a new and improved valve assembly and a cartridge construction that completely halts fluid flow through the gun when the actuator or trigger for the valve mechanism is released.

BACKGROUND OF THE INVENTION

To remove unwanted deposits from various surfaces as noted above, a fluid stream should be employed which has a pressure in the range of about 5,000–20,000 psi, and typically about 10,000 psi. Such high pressure fluid streams can be controlled by a spray gun device which includes a body having a high pressure outlet to discharge the high pressure stream, and a low pressure "dump" outlet that relieves much of the pressure of the outlet stream when blasting is to be discontinued. A portion of the fluid flow through the body is directed to the dump outlet by a valve mechanism which is operably responsive to a hand-operated trigger. An example of the above dump-valve blast gun system is disclosed and as claimed in U.S. Pat. No. 4,602,740 issued Jul. 29, 1986, which is incorporated herein by reference.

Although blast guns built in accordance with the above-mentioned patent have numerous advantages and desirable features, in some applications is it desirable for economic reasons to minimize the volume of cleaning fluid that is used by eliminating the low pressure dump port. In that event the high pressure fluid stream must be controlled by a valve assembly which totally halts or shuts off the flow of high pressure fluid toward the outlet when the stream is to be stopped. Such a valve should also include an actuating lever, in the form of a trigger, by which the operator holds the valve closure member open unless and until such trigger is released, at which time the closure member should seat to shut off the flow.

The above-referenced U.S. Pat. No. 4,602,740 represents a different design approach in that a bypass valve mechanism, which prohibits during flow therethrough so long as a trigger handle is operatively engaged during blasting, is dimensioned such that a hydraulic bias force tends to shift the valve element toward its open or dump position. Thus when the trigger is released by the operator for any reason, the valve automatically opens to allow blast fluid to bypass therethrough so that the pressure and flow through the outlet of the gun are reduced. However in a shut-off type gun to which the present invention relates, a hydraulic or other bias force on the closure element in the opening direction is highly undesirable because the valve may not close when the actuator lever or trigger is released by the operator.

The opening and closing of the valve element to either start or stop the high pressure flow of the blasting medium results in sliding friction and wear between the closure element and its housing. Many closure elements are housed in a body that is a large, expensive component which retains high pressures and which, as the

closure element is used, undergoes a considerable amount of wear also. Although the valve closure element typically can be replaced, the body can become worn to the extent that seal rings blow out under pressure and/or higher trigger forces are needed to operate the gun. Eventually the valve body must be replaced to restore the gun to a workable, like-new conditions, which requires a very expensive overhaul thereof.

In addition to the wear on parts due to sliding movement, damage to the valve seat surface can occur when foreign particles such as sand and rust in the fluid stream erode the seat surface as a high pressure fluid stream moves therepast at high velocity. Where such seat surface is formed on the valve body, time consuming and expensive overhaul is necessary to renew the gun assembly. Thus it is highly desirable to provide a valve closure element, and a housing or guide therefor which provides the seat in the form of a cartridge assembly that can be easily removed, repaired and replaced in the field, there being little chance of any wear problems with respect to the body itself since the critical wear surfaces are on the elements of the cartridge.

An object of the present invention is to provide a new and improved shut-off type high pressure blast gun where a hydraulic bias force is developed which tends to close the valve element and shut-off flow in the absence of an opening force thereon.

Another object of the present invention is to provide a new and improved shut-off blast gun of the type described which requires low actuating force in operation to reduce operator fatigue.

Still another object of the present invention is to provide a shut-off blast gun of the type described where the valve closure and its housing from a cartridge that is replaceable as a unit so that repair is easier; faster and less expensive than prior devices and can be readily accomplished in the field.

SUMMARY OF THE INVENTION

These and other objects are attained in accordance with the present invention through the provision of a fluid blast gun assembly including a body having an inlet for a source of fluid under high pressure, a discharge outlet for the high pressure fluid, and an internal chamber arranged to removably receive a valve cartridge assembly that controls the flow of high pressure fluid between the inlet and the outlet. The cartridge assembly includes a tubular housing or guide that fits into the chamber and carries axially spaced external seal rings which prevent leakage of fluids from the body along the chamber walls, and spaced internal seals that cooperate with a valve closure member included in the assembly. An internal inclined surface on the guide provides a valve seat that is located between upper and lower flow ports through the walls of the guide, and between the upper and lower internal seals. A valve closure member is slidably received in the bore of the guide and includes a leading end portion or head coupled to a trailing end portion by a reduced diameter central portion. The valve head has a surface that is inclined at a greater angle than the seat surface to form an edge at the outer periphery thereof which has line contact with the seat when the valve member is in its closed position. The trailing end portion of the valve member has an outer diameter that is slightly greater than the diameter of the leading end portion thereof and of the line contact of such edge with the valve seat so

that hydraulic pressure adjacent the valve element produce a resultant bias force that tends to shift or hold the valve head against the seat and thus shut off the flow of high pressure fluids. An additional bias force can be provided by a spring which forces the valve head toward the seat to close the valve in the closure of a hydraulic bias force.

The blast gun valve is actuated to the open position by a lever or trigger which employs mechanical advantage to overcome the bias forced and shift the valve element open when pressed by the fingers of an operator, so that the blast gun can be comfortably operated. When the operator relieves the pressure on the trigger, the valve element immediately shuts off the flow on account of being forced to the closed position by the hydraulic bias force. Since the guide, which is a part of the cartridge, remains stationary within the body during use, there is no wear on the body due to sliding friction between parts. The cartridge assembly is held in position in the body by means such as a threaded plug which is releasably coupled to the guide, so that the plug and cartridge can be readily removed and then replaced after any necessary field repairs.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention has other objects, features and advantages which will become more clearly apparent for the following detailed description of a preferred embodiment, taken in conjunction with the appended drawings in which:

FIG. **1** is a side elevation of the fluid blast gun of the present invention, with some parts shown in cross-section;

FIG. **2** is an enlarged elevational view of the valve cartridge shown in FIG. **1**, the left side being shown in section;

FIG. **3** is a further enlarged, fragmentary view of parts of the valve head and the seat; and

FIG. **4** is a view similar to FIG. **1** of another embodiment of the present invention.

DETAILED DESCRIPTION OF A PREFERRED EMBODIMENT

Referring initially to FIG. **1**, a fluid blast gun indicated generally at **10** includes a body **12** having an inlet **13** for a source of water under high pressure and an outlet **14** for the discharge of water under high pressure. The inlet **13** is connected by threads **15** to an inlet nipple (not shown) which has a suitable coupling at its outer end for connection to the water source, and the outlet **14** has threads **16** to attach a discharge nipple (not shown) having a nozzle assembly on its outer end which produces a jet or blast stream of water for use in various cleaning operations. A handle **17** which also provides a guard for a trigger **20** is connected to the body **12** by cap screws **9** or the like. The actuating trigger **20** is pivotally mounted on the body **12** by a pin **21**, and pivots between a forward position, as shown, where fluid flow through the gun **10** is shut off and a rearward position against a stop where flow is permitted. The trigger **20** is provided with a tang **22** on its upper end which actuates a flow control valve assembly **25** to be described in detail below. The trigger **20** and the tang **22** preferably are dimensioned to provide a mechanical advantage of about 8:1 to correspondingly reduce the pressure on the trigger **20** needed to open the valve assembly **25**, and to hold it open.

The valve assembly **25** is removably mounted within a bore **26** formed in the body **12**, and is retained against downward movement by a stop shoulder **11**. The bore **26** opens through both the top and the bottom of the body **12**, and has reduced diameter seal shoulders **27–29** separated by increased diameter annular regions **30, 31** which are formed opposite the inlet and outlet ports **13, 14** respectively. The upper end portion of the bore **26** is enlarged and threaded at **32**, and receives a threaded plug **33** by which the valve assembly **25** is positioned and held in the body **12**, and removed therefrom when needed. The plug **33** has an internal bore **34** which is vented by several radial holes **35** to prevent pressure build-up inside same. The lower end portion of the nut **33** is coupled to the cartridge **25** by a semi-annular recess **36** therein which reconnect an annular flange **37** on the upper end of the valve cartridge **25**. The flange **37** is engaged laterally within the recess **36** prior to inserting the cartridge **25** into the bore **26**.

FIG. **2** is an enlarged view which shows further structural details of the valve cartridge assembly **25**. The cartridge assembly **25** includes a generally tubular housing member or guide **40** and a valve assembly **41** slidably mounted therein. The housing member **40** has axially spaced, outwardly extending shoulders **43–45** which have external annular grooves **46–48** that receive seal rings **50–52** and back-up rings **53–55**. Internal annular grooves **56, 57** are formed inside the shoulders **43** and **45** and receive seals **58, 60** which preferably are mounted on plastic rings **61, 62** that enable very low friction and sliding movement of the valve assembly **41** therethrough. A first plurality of angularly spaced flow ports **63** extend through the wall of the guide **40** between the shoulders **43** and **44**, and a second plurality of angularly spaced flow ports **63'** extend through such wall between the shoulders **44** and **45**. A frusto-conical wall surface **64** is formed inside the body **40** adjacent the shoulder **44** and provides an inclined valve seat which cooperates with an edge on the valve assembly **41** in the closed position thereof to shut off fluid flow as will be explained in further detail below. The upper end of the body **40** is provided with a neck **66** which has the outwardly directed flange **37** formed integrally therewith. The flange **37** cooperates with the lower end of the threaded plug **33** to enable the cartridge assembly **25** to be inserted into, and removed from the bore **26** of the spray gun body **12** as disclosed above.

The valve closure member **41** includes a cylindrical leading portion or head **70**, a cylindrical trailing member **71**, and a reduced diameter central portion **72**. The lower end of the central portion **72** is threaded at **73** to the trailing member **71** so that the head **70**, the portion **72** and the trailing member **71** form a unitary assembly. The lower side of the head portion **70** has an inclined lower surface **74** that is formed on a slightly steeper angle with respect to the longitudinal axis of the closure member than the seat surface **64** as shown in FIG. **3**, so that the outermost edge **75** of the head **70** engages the seat surface with a line contact when the valve is closed as shown in the drawings. The diameter D_1 of such line contact (FIG. **2**) is slightly less than the diameter D_2 of engagement of the seal **61** with the outer diameter of the trailing valve element portion **71** so that when high pressure fluid is present in the annular region **76** that surrounds the neck **72** of the valve closure member **41**, a hydraulic bias force is generated which tends to hold the member in its closed position.

The trailing portion **71** of the closure element **41** includes an outwardly directed flange **80** on its lower end which provides a rounded or domed surface **81** that is engaged by the tang **22** of the actuator trigger **20**. The upper side **82** of the flange **80** is engaged by the lower end of a coil spring **83** whose upper end presses against the lower face **84** of the cartridge housing **40**. The spring **83** provides an additional bias force that tends to hold the valve closure element **41** in its closed position, primarily when the gun **10** is not in operation. A skirt **85** can be formed on the upper end of the trailing portion **71** which extends parallel to the axis of the member **71** until after the threads **73** are made up. Then a suitable punch or other tool can be inserted through the flow ports **63** in order to crimp the skirt **85** inward above the threads in order to positively prevent them from unthreading during use.

A blind bore **38** on the upper side of the body **12** has threads **39** to attach a tube (not shown) having a shoulder rest mounted on its outer end. Such rest allows the user's shoulder to comfortably absorb reaction forces while the blast gun **10** is in operation. Although not shown in the drawing, a stub pipe which is screwed with another blind bore on the left side of the body **12** can be grasped by the other hand of the operator to further stabilize the gun in use.

OPERATION

In use, the spray or blast gun **10** is assembled as shown in the drawings, and a source of high pressure fluid is connected to the inlet line **15** by a suitable coupling (not shown). So long as the trigger **20** is not depressed or pivoted rearward, the valve assembly **25** blocks fluid communication between the inlet port **13** and the outlet port **14** which has the tube **16** and nozzle (not shown) connected thereto. The hydraulic bias force acting downward on the valve closure member **41**, as supplemented by the bias force of the spring **83**, holds the valve head **70** in its closed position with a resultant force that increases with increasing pressures.

To open the closure member **41** so that blasting operations can commence, the trigger **20** is pressed rearward to cause the tang **22** on the upper end thereof to pivot upward about the pin **21**. Such movement forces the closure element **41** upward in the guide **40** and disengages the edge **75** from the seat surface **64** in order to place the inlet port **13** in communication with the outlet port **14** via the flow ports **63, 63'** and the annular region **76** between the center valve element portion **72** and the surrounding inner surfaces of the guide **40**. Since the diameter D_1 is less than the diameter D_2, the pressure of fluids produces a downwardly directed hydraulic bias force on the valve element **41** which tends to return the same to its closed position, such force being determined by the following formula:

$$F = P \cdot \frac{(D_2^2 - D_1^2)}{4} \cdot \pi$$

Where F=force in lbs.
P=pressure in lbs. per inch^2,
D_2=diameter of trailing portion **71** in inches;
D_1=diameter of leading portion **41** or line contact **75** in inches;
π=a constant of approximately 3.1416

However the actuating force on the trigger **20** and the mechanical advantages provides for a net opening force that is low enough to prevent operator fatigue in normal operations. The coil spring **83** also contributes a closing force, however its force is present primarily to maintain the valve closed when not in use.

As an example of the bias forces, but not by way of limitation, the difference between the diameters D_1 and D_2 can be about 0.006–0.008 inches, and the parts are sized such that each 0.001 inch of diameter difference results in approximately 10 lbs. of closing force at an operating pressure of 10,000 psi. In view of the mechanical advantages provided in the design of the trigger **20**, only about 5–7 lbs. of rearward force on it is sufficient to maintain the valve closure element **41** open, or to open it once the edge **75** has been closed against the seat **64**.

Although the coil spring **83** has been disclosed as a means to supplement the bias force in the closing direction .on the valve **41**, its primary function is to maintain the valve closed when not in use. Such spring can be considered to be unnecessary to the overall operation of the gun **10**, and may be omitted. However the spring **83** will ensure that the valve **41** is closed in the absence of fluid pressure at the inlet port **13**, or at very less pressure.

From the foregoing, it will be recognized that since any wear due to sliding friction is confined to the cartridge assembly **25** and its component parts, the likelihood that the valve body **12**, which is a large and expensive part, will experience wear to the point of needing replacement is quite remote. On the other hand the cartridge **25** can be easily removed from the body **12** and its various parts renewed or replaced very easily by simply removing the threaded plug **33** and pulling the cartridge **25** out of the body **12**. Thus the blast gun **10** lends itself to field repair which is a significant advantage.

The hydraulic bias afforded by the structural relationship of the parts of the present invention forces the valve closure element **41** toward its closed position at all times during blasting operations. Thus any time that actuating pressure on the trigger is released, either purposely or accidentally, the valve will automatically close and stop the flow of high pressure blast fluids. The valve seat **64** is made integral with the housing **40** so that precise coaxial alignment of the bore and seat can be formed during manufacture. The valve closure element **41** also has both its seal diameters and its seat machined in one operation for precise coaxial alignment.

Another embodiment of the present invention which is adapted to be actuated by the foot of the operator rather than by hand is shown in FIG. **4**. Here the valve body **100** is mounted in a secure manner on a base plate **101** which extends well to the rear of the body. An upstanding cage indicated generally at **102** having front and rear U-shaped members **103, 104** connected by cross members **105–107** provides a skeletal enclosure for an actuating pedal or lever **108** which is pivoted to the body **100** by a pin **110**. A tang **111** on the inner end of the pedal **108** extends into a recess **112** in the body **100** where the end surface **109** thereof engages the head **113** of the valve closure element **115** of the cartridge assembly **114**. The cartridge assembly **114** includes the closure element **115**, and a ported housing member **116** which is received in a longitudinal housing bore **117**. The cartridge assembly **114** is identical to that described above respecting FIGS. **1–3** and thus need not be described again in detail. As in the previous embodiment,

the cartridge assembly **114** is removably held in place in the body bore **117** of a vented nut **120**.

The valve body **100** is provided with a transverse threaded inlet **121** and a transverse threaded outlet **122** to which a source of fluid under pressure and a spray nozzle are respectively attached. The inlet **121** is connected to recessed region **123** of the bore **117** by a port **119**, and the outlet **122** is similarly connected to the body region **124** by a port **125**. Ports **126, 127** leading from these regions to the outside of the body **100** are closed off by plugs **130, 131**.

The embodiment shown in FIG. **4** operates in essentially the same manner as the previous embodiment except that the assembly is placed on the floor and the toe portion of the operator's boot is used to press down on the pedal **108** to shift the closure element **115** forward in the housing **116** and thereby communicate the inlet and outlet ports **121,122**. A forward acting bias force on the closure element **115**, as described above, tends to return the closure element to its rearward or closed position. Thus any time the foot of the operator is removed from the pedal **105**, either purposely or otherwise, the valve element **115** automatically closes and shuts off high pressure flow. Both embodiments have a "fail-safe" operation in this regard.

It now will be recognized that a new and improved shut-off blast gun has been disclosed which meets all of the objections of the present invention, and which incorporates numerous unique features and advantages as set forth herein. Since certain changes or modifications may be made in the disclosed embodiment without departing from the inventive concepts involved, it is the aim of the appended claims to cover all such changes and modifications falling within the true spirit and scope of the present invention.

What is claimed is:

1. Valve apparatus for use in a high pressure fluid blast cleaning operations, comprising: a body having an inlet for a source of fluid under high pressure and an outlet for the discharge of fluid under high pressure, said body having a bore communicating said inlet and said outlet; tubular guide means removably positioned in said bore and defining a valve seat; valve means positioned in said guide means and having a closure element movable longitudinally between a closed position where said element engages said seat to shut off flow between said inlet and outlet and an open position where said element is spaced from said seat to permit flow from said inlet to said outlet; hydraulically operable means including a resultant transverse area of said valve means responsive to said pressure for biasing said valve means toward said closed position, said biasing means being defined in part by a first diameter of engagement of said closure element with said seat and a second diameter of sealing contact between said valve means and said guide means, said first diameter being less than said second diameter to provide said resultant transverse area so that said pressure generates force which tends to shift said closure element against said seat; and actuating means for shifting said valve means to said open position.

2. The apparatus of claim **1** wherein closure element and said seat are shaped to provide annular line contact therebetween.

3. The apparatus of claim **1** wherein said seat is formed by an inclined surface and said valve element has an inclined surface with a greater inclination angle than said seat, so that said valve element has an annular edge which engages said seat surface with line contact.

4. The apparatus of claim **1** wherein said guide means has first flow port means below said seat for communicating said inlet with the interior thereof and second flow port means above said seat for communicating said interior with said outlet.

5. The apparatus of claim **1** further including means releasably connected to said body for positioning said guide means and said valve means in said bore and for removing same from said bore.

6. The apparatus of claim **5** wherein said positioning and removing means includes a plug member threaded into said body in coaxial alignment with said bore, said plug member having means on the inner end thereof for releasable connection with said guide means.

7. The apparatus of claim **1** further including supplemental means for biasing said valve means toward said closed position.

8. The apparatus of claim **7** wherein said supplemental biasing means includes a coil spring reacting between said guide means and said valve means.

9. A valve cartridge assembly for use in a high pressure water blast gun, comprising: a generally tubular guide member having axially spaced flow ports and an internal inclined seat surface arranged between said flow ports; and a valve element slidably positioned in said guide member, said valve element including a head portion having sealing contact with said guide member and adapted to engage said seat to prevent fluid flow through said blast gun, said valve element further including a trailing portion having an outer surface that is sealed with respect to said guide member on a diameter that is greater than the diameter of said sealing contact of said head portion, the difference in transverse areas defined by said diameters producing a hydraulic bias force which tends to shift said valve head against said seat.

10. The valve cartridge assembly of claim **9** wherein said head portion and said trailing portion are joined together by a reduced diameter center portion whose external walls together with internal walls of said guide member define a flow path between said axially spaced flow ports.

11. The valve assembly of claim **10** further including threaded connector means between said trailing portion and said central portion; outwardly directed shoulder means on said trailing portion; and spring means reacting between said shoulder means and said guide member providing a mechanical bias force which acts in the same direction as said hydraulic bias force and also tends to close said valve element against said seat.

12. The valve assembly of claim **11** further including connection means on said guide member; and releasable means attached to said connector means to enable said valve assembly to be positioned in and removed from an associated valve body.

13. A valve closure element for use in a high pressure water blast gun, comprising: a cylindrical leading portion and a cylindrical trailing portion connected to one another by a reduced diameter central portion, said leading portion providing a valve head and having an outer diameter; means on said valve head adapted to engage a seat surface to prevent fluid flow, said trailing portion having an outer diameter that is greater than said outer diameter of said leading portion to define a differential area on which pressures can act to force said valve head against the seat.

14. The valve closure element of claim 13 including thread means for rigidly connecting said trailing portion to said central portion.

15. The valve closure element of claim 14 further including deformable means for preventing unthreading of said thread means.

16. The valve closure element of claim 13 when said trailing portion has an outwardly directed shoulder thereon adapted to be engaged by a spring means which provides a supplemental bias force to said valve closure element.

17. Valve apparatus for use in a high pressure fluid blast cleaning operation, comprising: a valve body having an inlet for a source of fluid under high pressure and an outlet for the discharge of fluid under high pressure, said body having a bore communicating said inlet and said outlet; tubular guide means removably positioned in said bore and defining a valve seat; valve means positioned in said guide means and movable between a closed position where said element engages said seat to shut off flow between said inlet and outlet and an open position where said element is spaced from said seat to permit flow from said inlet to said outlet; hydraulically operable means including a resultant transverse area of said valve means for biasing said valve means toward said closed position in response to pressure at said inlet, said resultant transverse area being defined in part by a first, lesser diameter of engagement of said valve means with said guide means and a second, greater diameter of sealing contact of said valve means with said guide means; and foot-operated means for shifting said valve means to said open position against the bias of said hydraulically operable means.

18. The apparatus of claim 17 wherein said valve body is mounted on a plate means that is arranged to rest on a floor surface, and wherein said foot-operated means is a longitudinally extending pedal pivoted for movement in a vertical plane at its inner end to said body.

19. The apparatus of claim 18 further including cage means for protecting said pedal against accidental operation.

* * * * *